US00RE42614E

(19) **United States**

(12) **Reissued Patent**

Dring et al.

(10) **Patent Number: US RE42,614 E**

(45) **Date of Reissued Patent: Aug. 16, 2011**

(54) **SYSTEM AND METHODS FOR MONITORING CAREGIVER PERFORMANCE**

(75) Inventors: **Barton Dring**, River Forest, IL (US); **John Ross**, Elmhurst, IL (US)

(73) Assignee: **ProactiCare LLC**, Hinsdale, IL (US)

(21) Appl. No.: **12/661,690**

(22) Filed: **Jan. 21, 2010**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **7,541,935**
Issued: **Jun. 2, 2009**
Appl. No.: **11/133,405**
Filed: **May 19, 2005**

(51) **Int. Cl.**
G08B 23/00 (2006.01)

(52) **U.S. Cl.** **340/573.1**; 340/533; 340/539.16; 340/665; 600/595

(58) **Field of Classification Search** ..... None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,439,358	A		4/1969	Salmons
4,228,426	A		10/1980	Roberts
4,295,133	A		10/1981	Vance
4,320,766	A	*	3/1982	Alihanka et al. 600/595
4,633,237	A		12/1986	Tucknott et al.
4,638,307	A		1/1987	Swartout
4,700,180	A		10/1987	Vance
4,827,763	A	*	5/1989	Bourland et al. 73/172
4,907,845	A	*	3/1990	Wood 340/573.4
5,235,319	A		8/1993	Hill et al.
5,353,012	A		10/1994	Barham et al.
5,410,297	A	*	4/1995	Joseph et al. 340/573.7
5,471,198	A		11/1995	Newham
5,519,380	A		5/1996	Edwards
5,633,627	A		5/1997	Newham
5,699,038	A		12/1997	Ulrich et al.
5,780,798	A		7/1998	Hall-Jackson
6,025,782	A		2/2000	Newham
6,078,261	A		6/2000	Davsko
6,111,509	A		8/2000	Holmes
6,133,837	A		10/2000	Riley
6,208,250	B1		3/2001	Dixon et al.
6,252,512	B1		6/2001	Riley
6,297,738	B1		10/2001	Newham
6,307,476	B1		10/2001	Smith et al.
6,362,725	B1		3/2002	Ulrich et al.
6,546,813	B2		4/2003	Hubbard
6,778,090	B2		8/2004	Newham
6,784,797	B2		8/2004	Smith et al.
6,788,206	B1		9/2004	Edwards
2002/0151990	A1		10/2002	Ulrich et al.

(Continued)

OTHER PUBLICATIONS

Sturgeon, Jeff, Smart Bed, The Roanoke Times, Feb. 1, 2004.

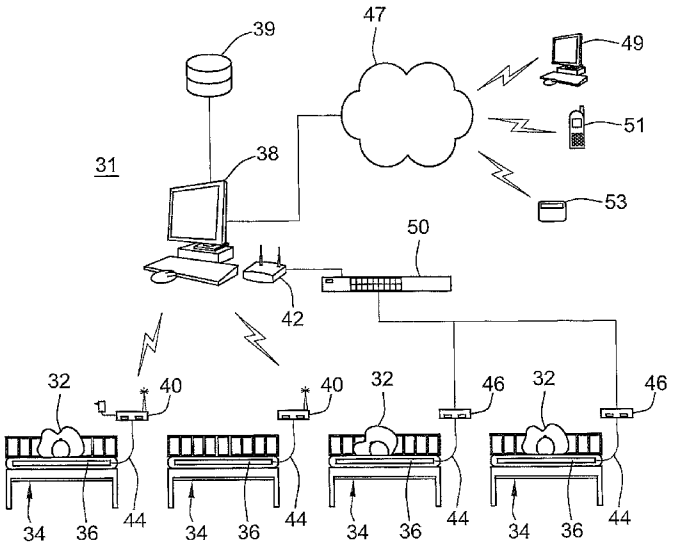
Primary Examiner — Thomas J Mullen

(74) *Attorney, Agent, or Firm* — Valauskas Corder LLC

(57) **ABSTRACT**

Systems and methods for monitoring the performance of a caregiver are disclosed. The systems may be configured to monitor the movement of each **[**caregiver**]** *subject* in a network of **[**caregivers**]** *subjects*. One such system includes a plurality of strips adhered in spaced-apart relation on a mattress pad, upon which a subject is positioned. One or more transmitter is provided coupled to the plurality of strips. A processor is connected to the one or more transmitter. The processor is provided with operating software to record and report caregiver activity or both caregiver activity and subject activity.

22 Claims, 20 Drawing Sheets



Amended

U.S. PATENT DOCUMENTS

2003/0136201 A1 7/2003 Hubbard
2003/0187618 A1 10/2003 Inda et al.
2003/0227386 A1* 12/2003 Pulkkinen et al. 340/573.1
2004/0046668 A1* 3/2004 Smith et al. 340/573.7
2005/0011738 A1* 1/2005 Smith et al. ..... 200/85 R
2006/0028350 A1* 2/2006 Bhai 340/666

* cited by examiner

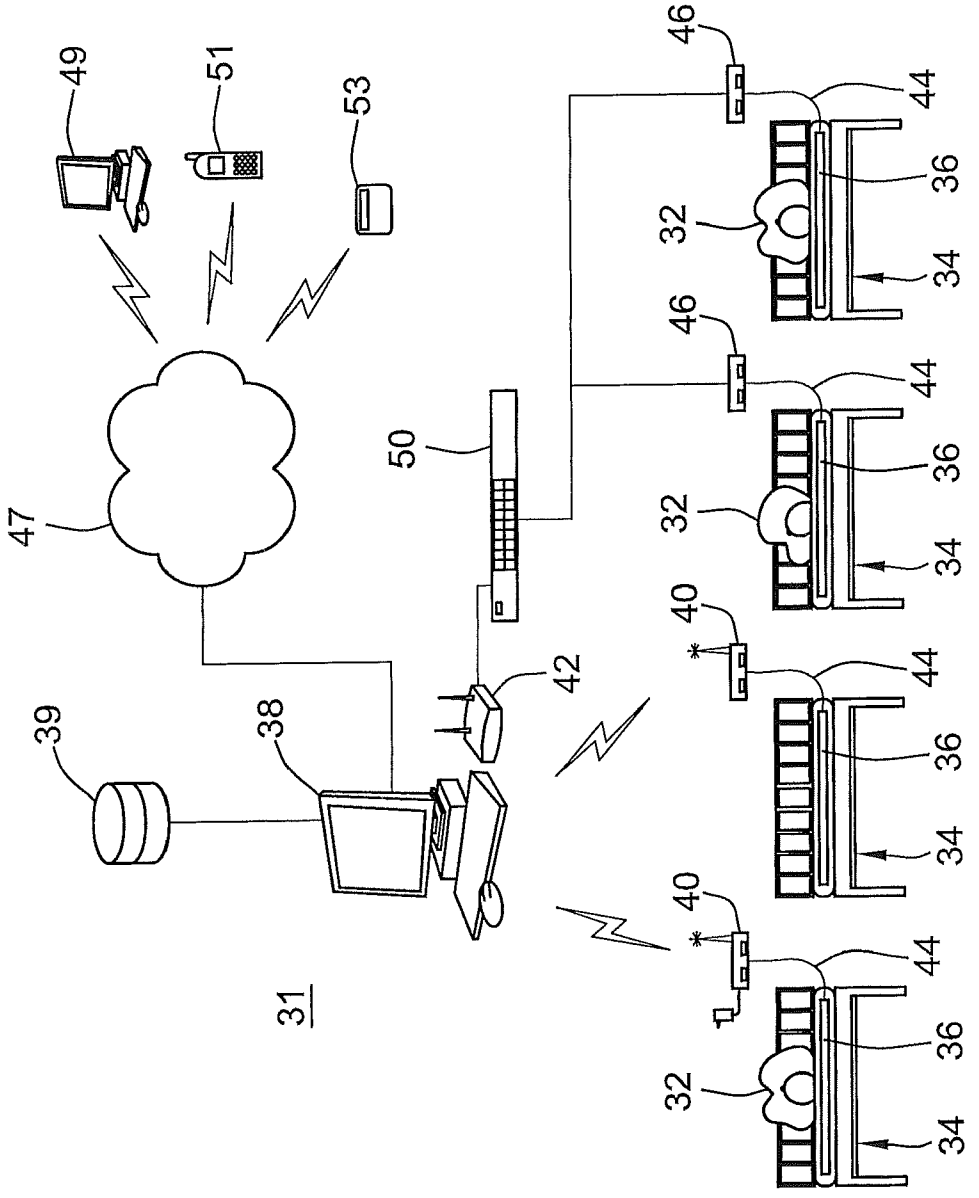


FIG. 1
Amended

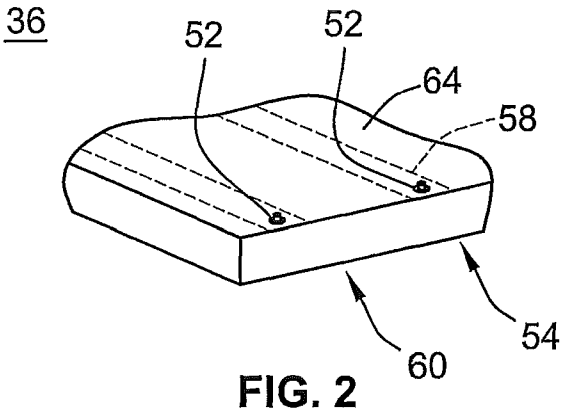


FIG. 2
Amended

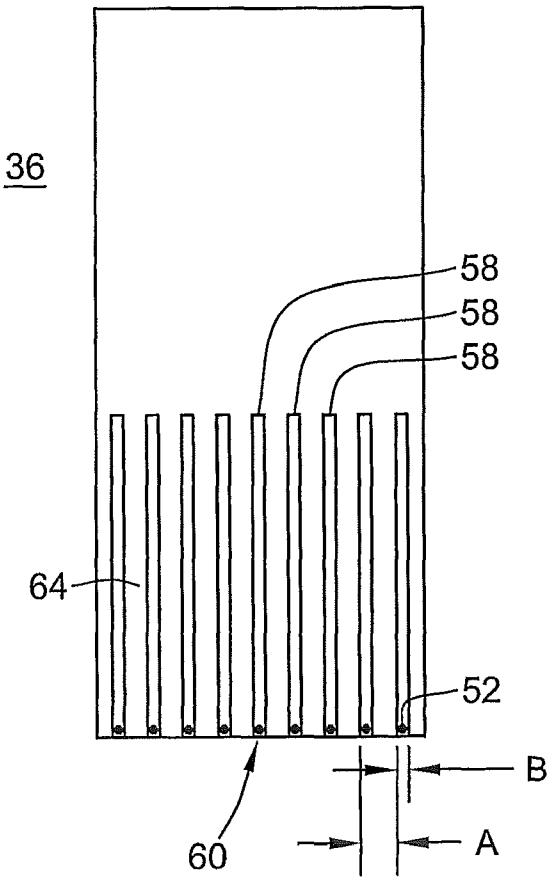


FIG. 3
Amended

FIG. 4
Amended

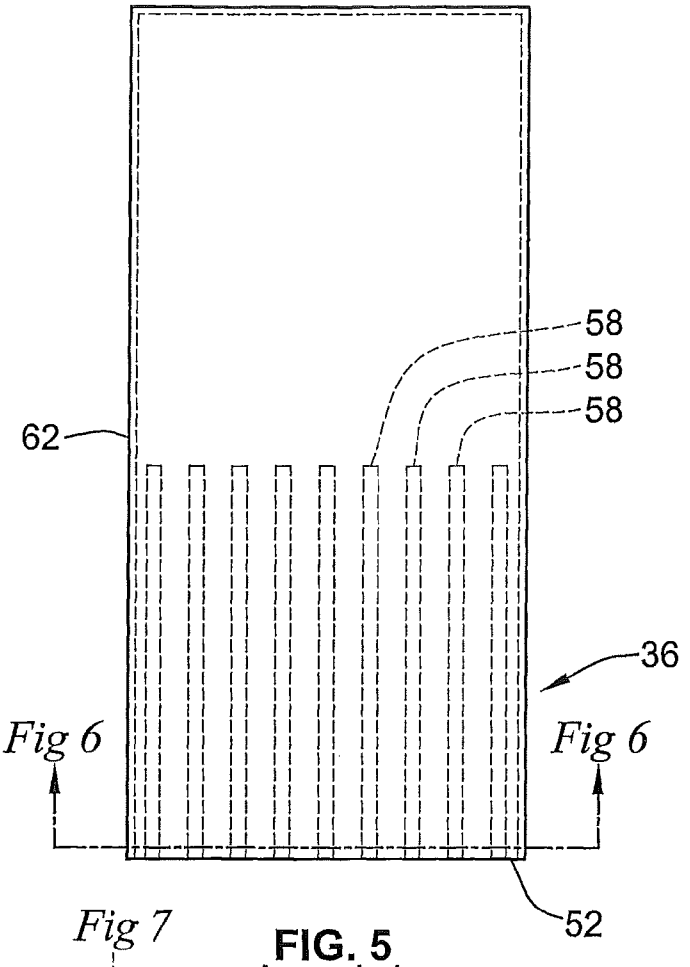


FIG. 5
Amended

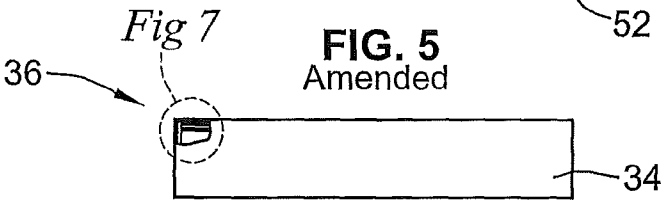


FIG. 6
Amended

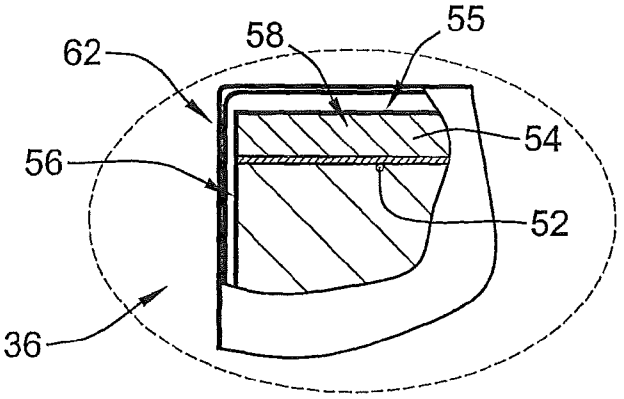


FIG. 7
Amended

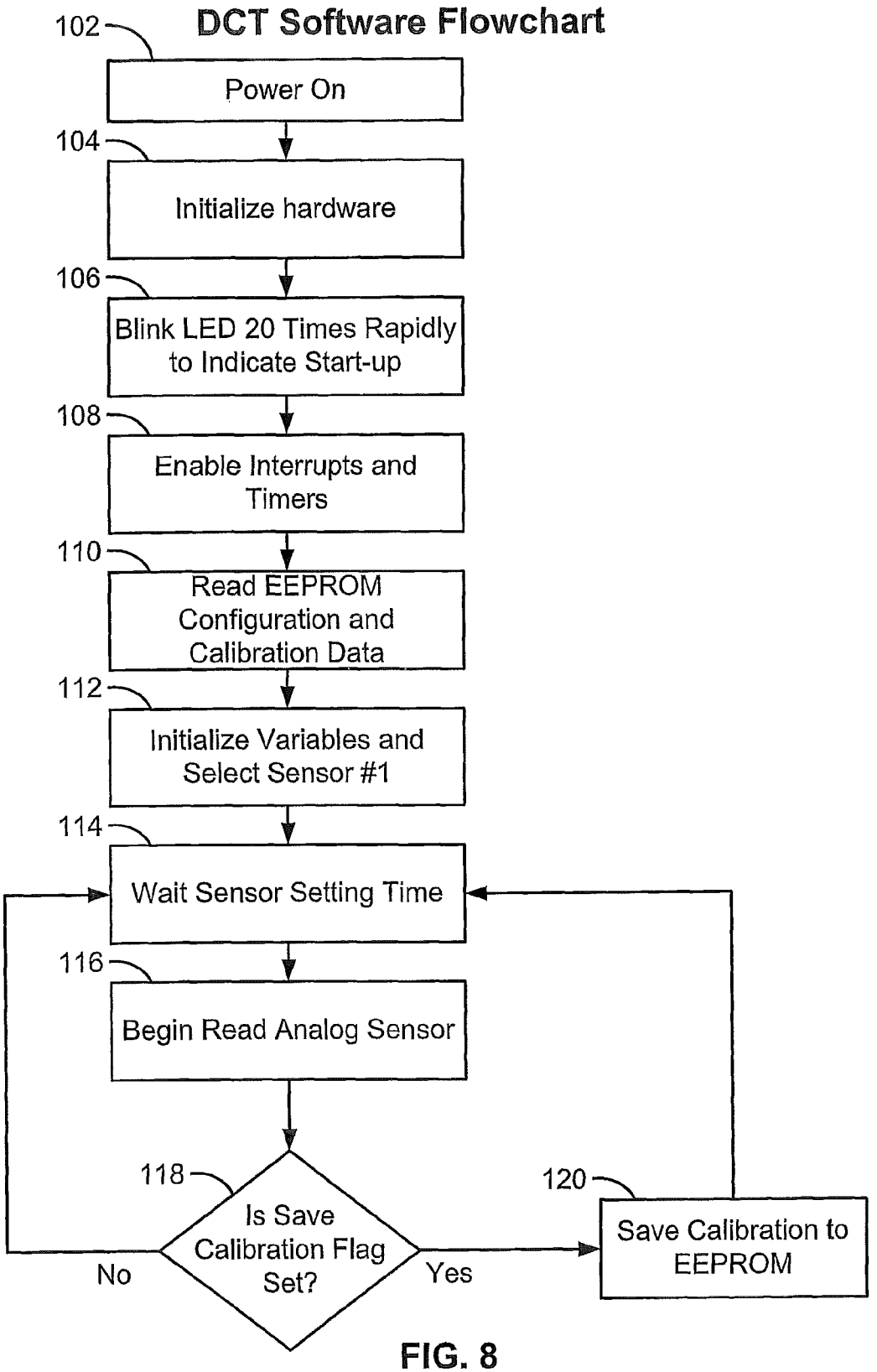


FIG. 8
Amended

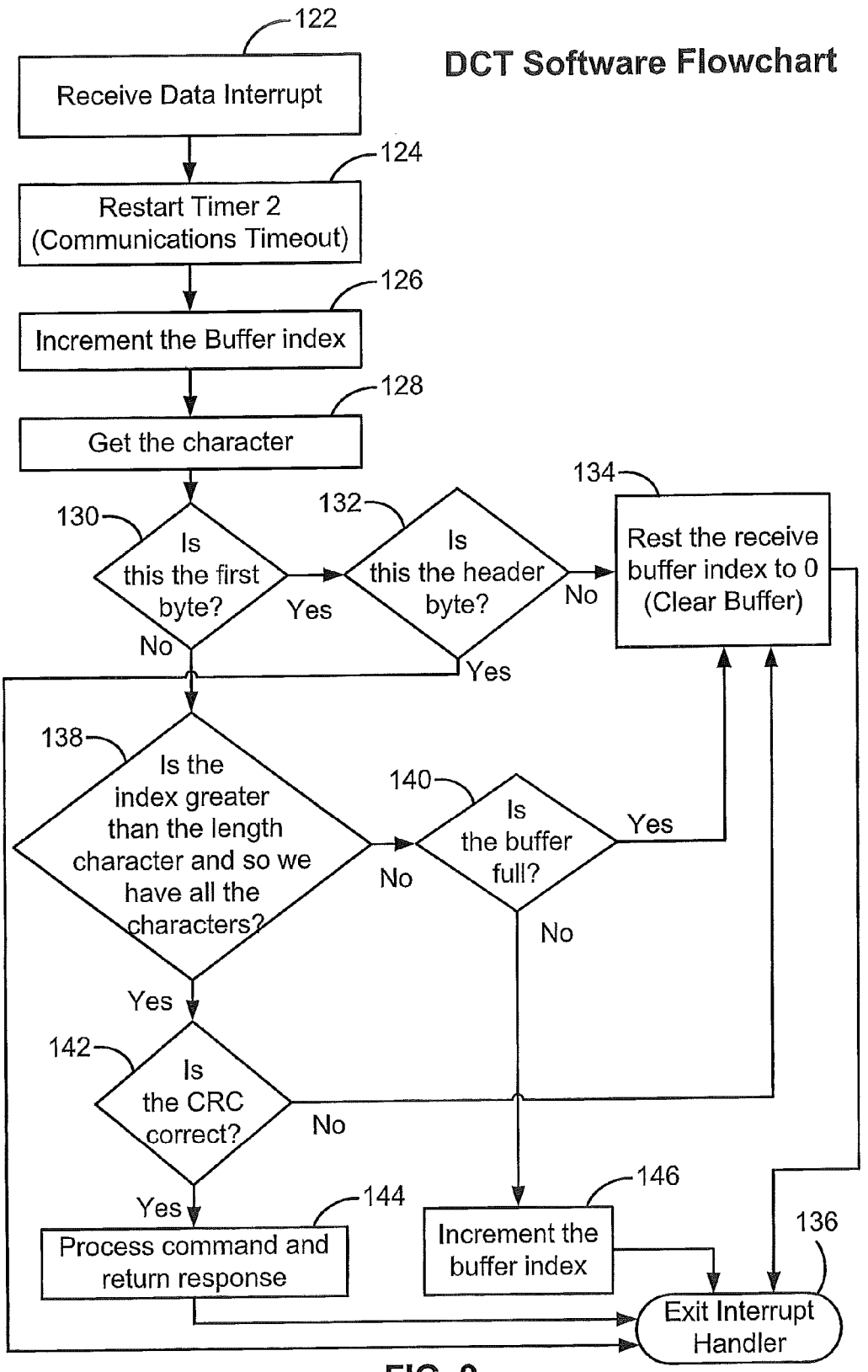


FIG. 9
Amended

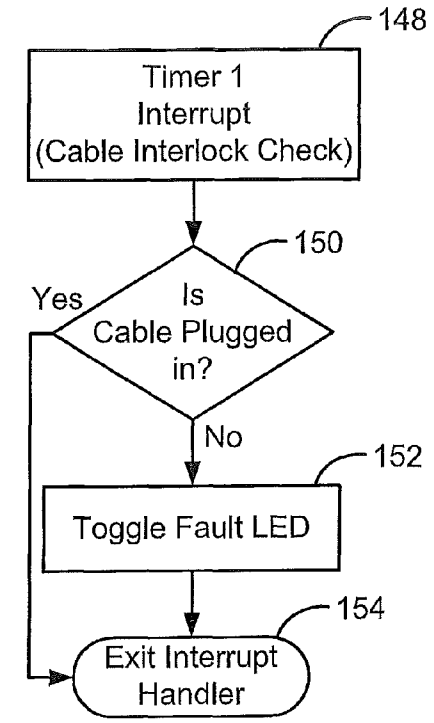


FIG. 10
Amended

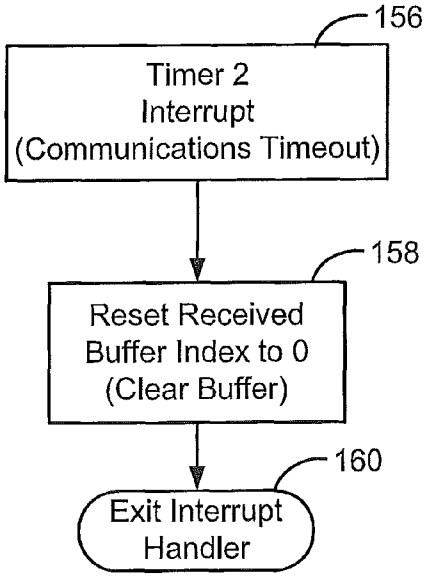


FIG. 11
Amended

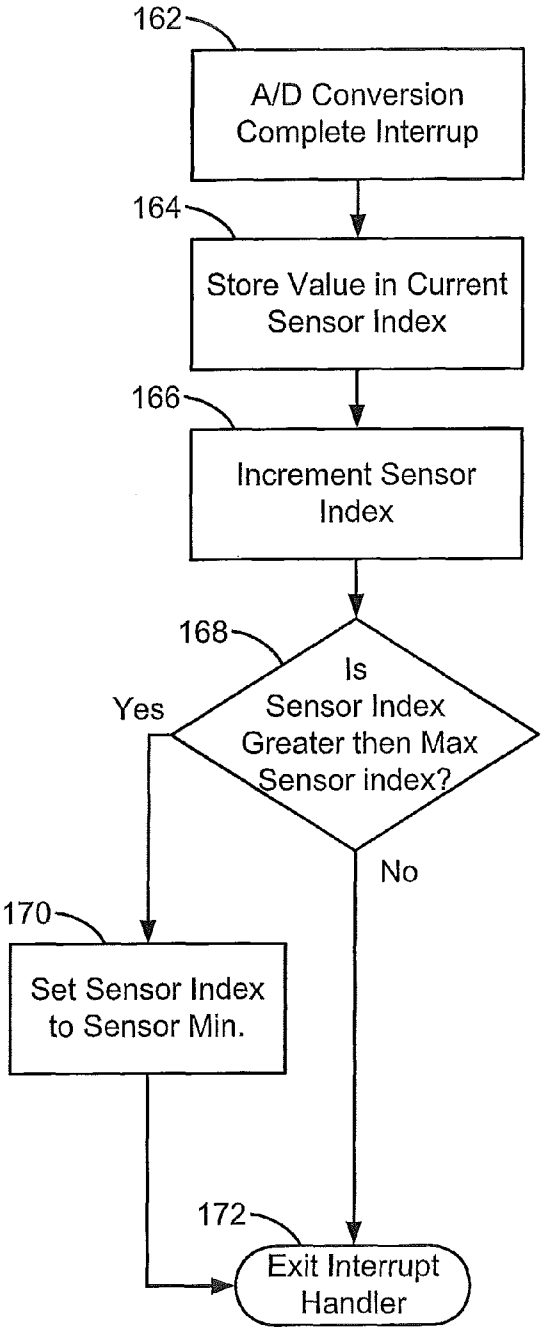


FIG. 12
Amended

DCT Software Flowchart

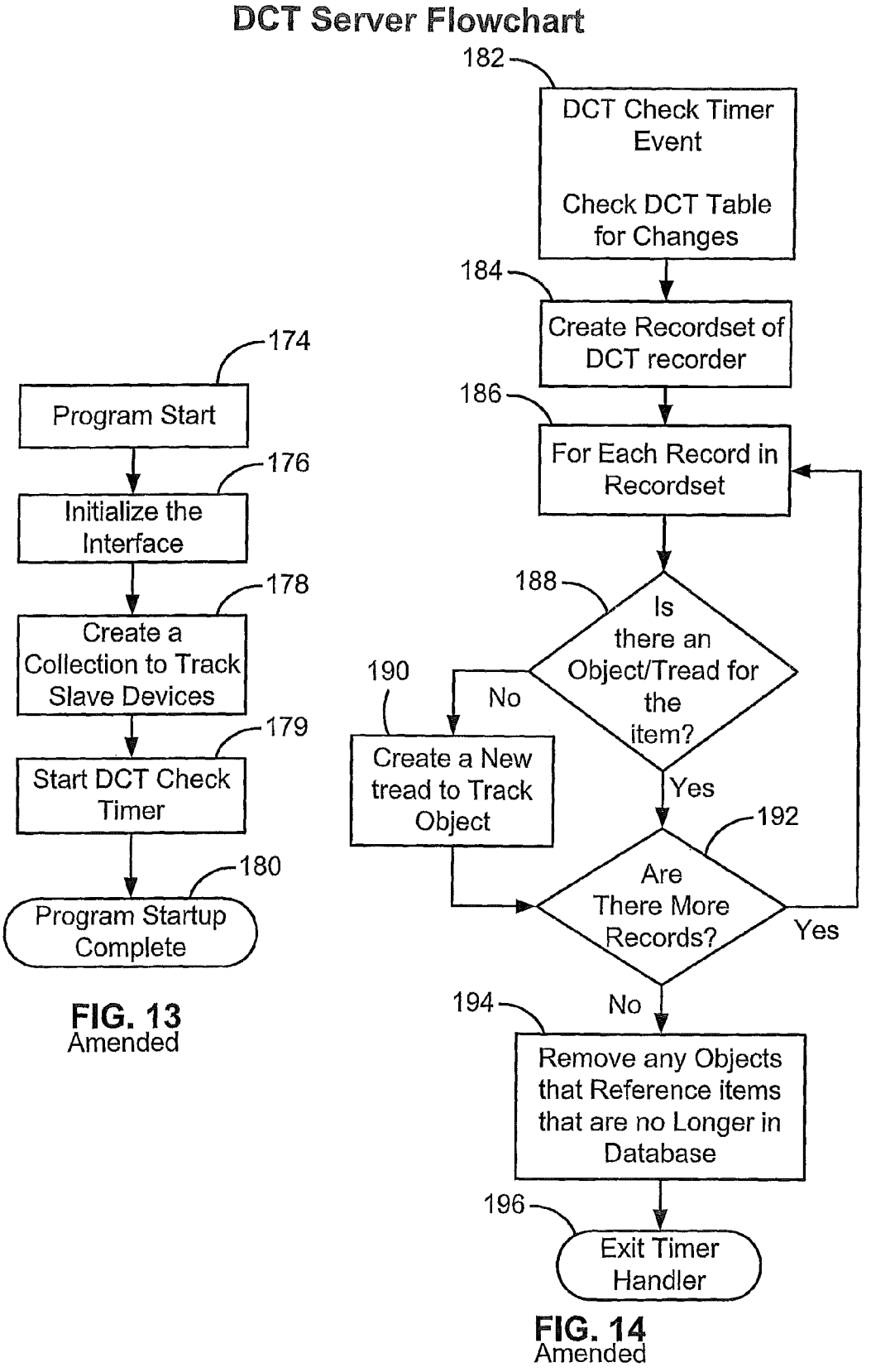


FIG. 13
Amended

FIG. 14
Amended

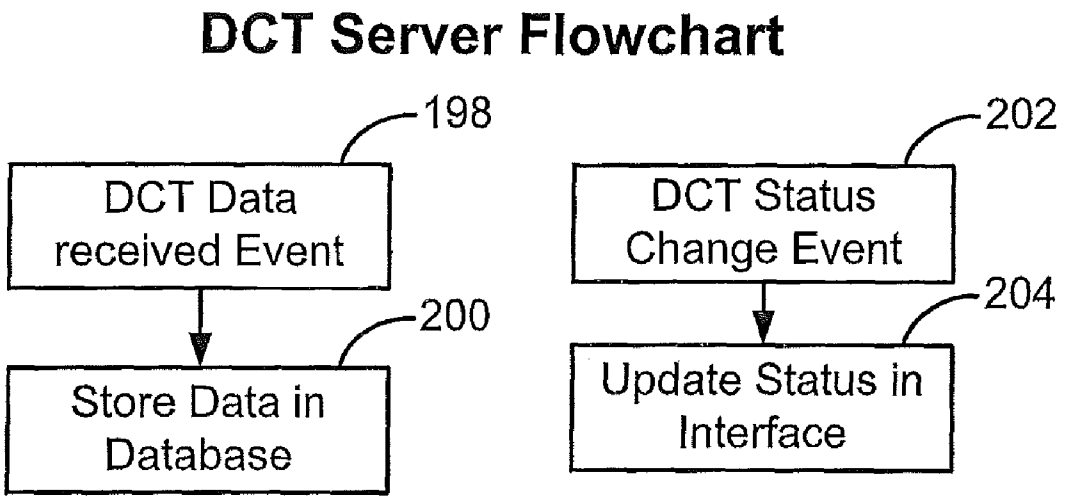


FIG. 15
Amended

FIG. 16
Amended

DCT Server Flowchart

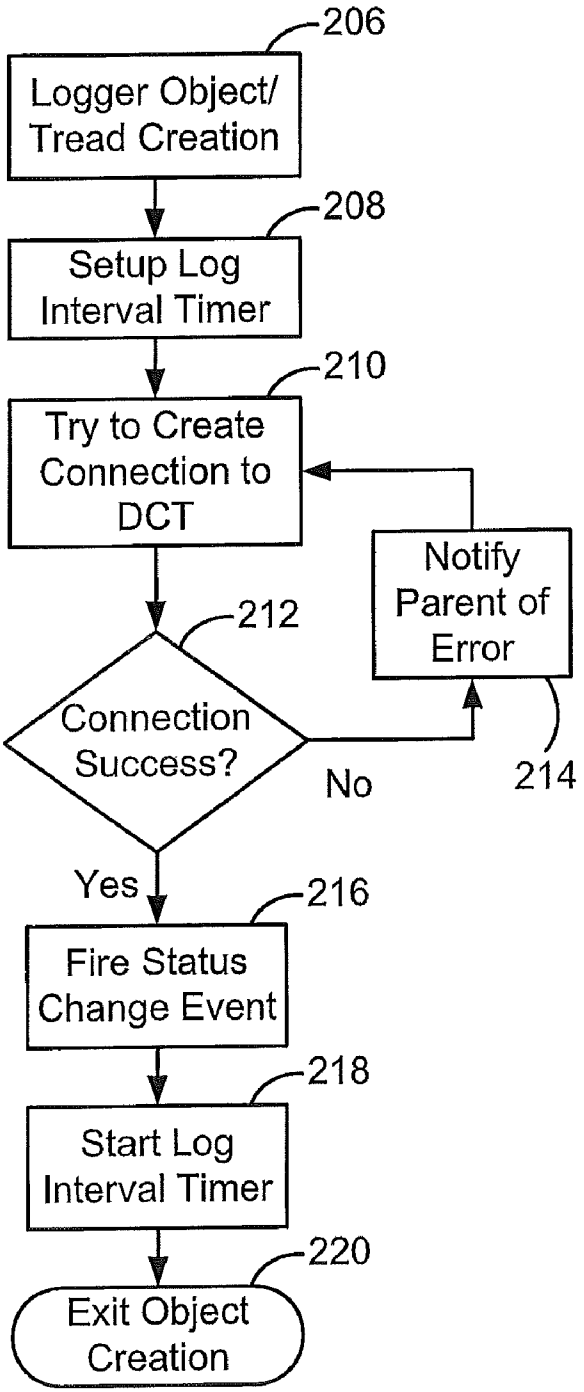


FIG. 17
Amended

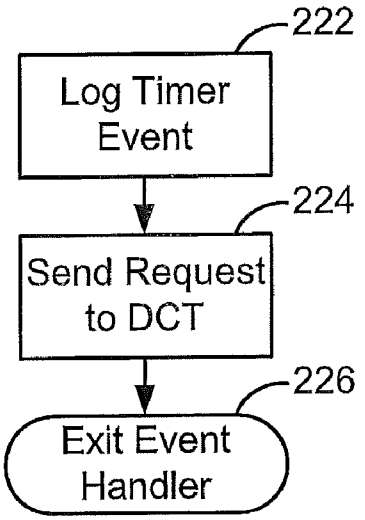


FIG. 18
Amended

DCT Server Flowchart

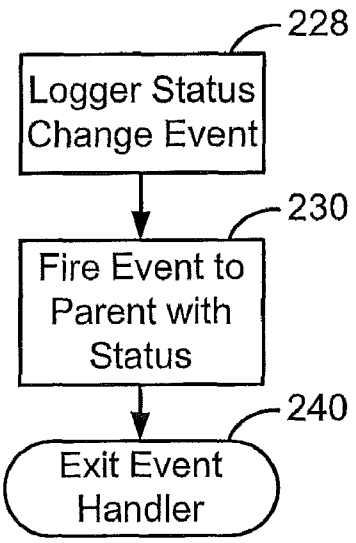


FIG. 19
Amended

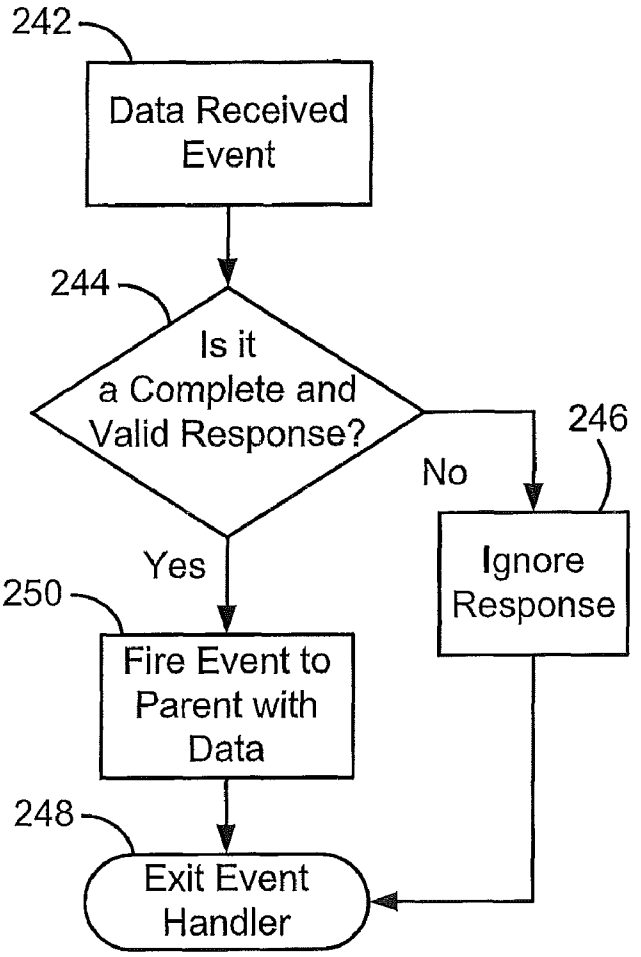


FIG. 20
Amended

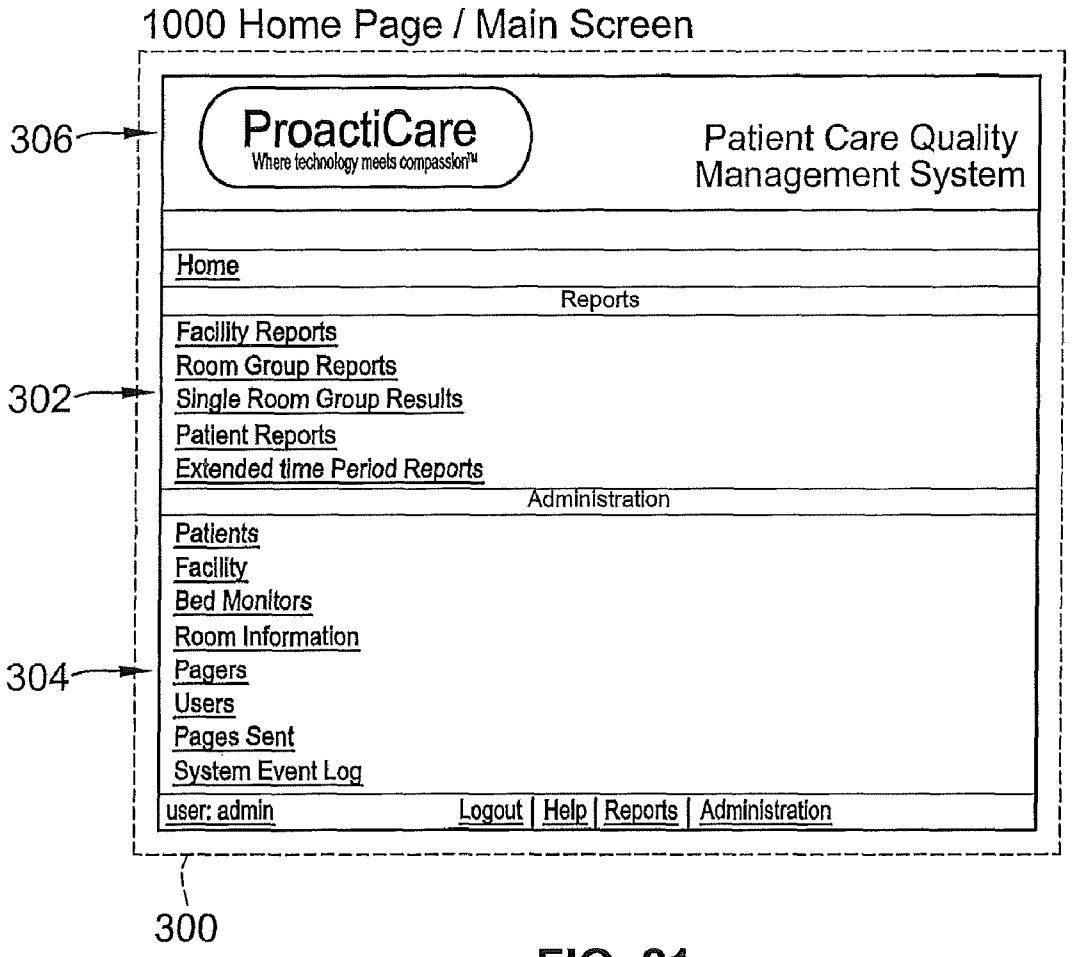


FIG. 21
Amended

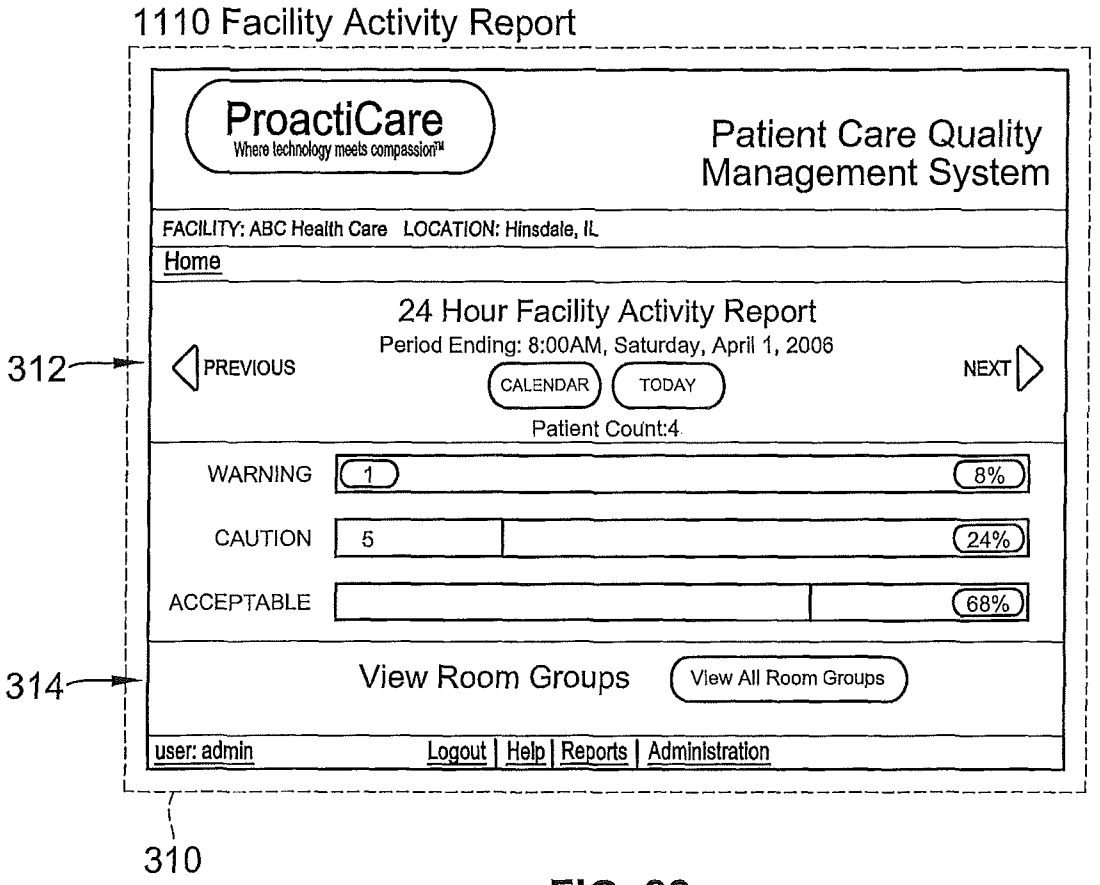
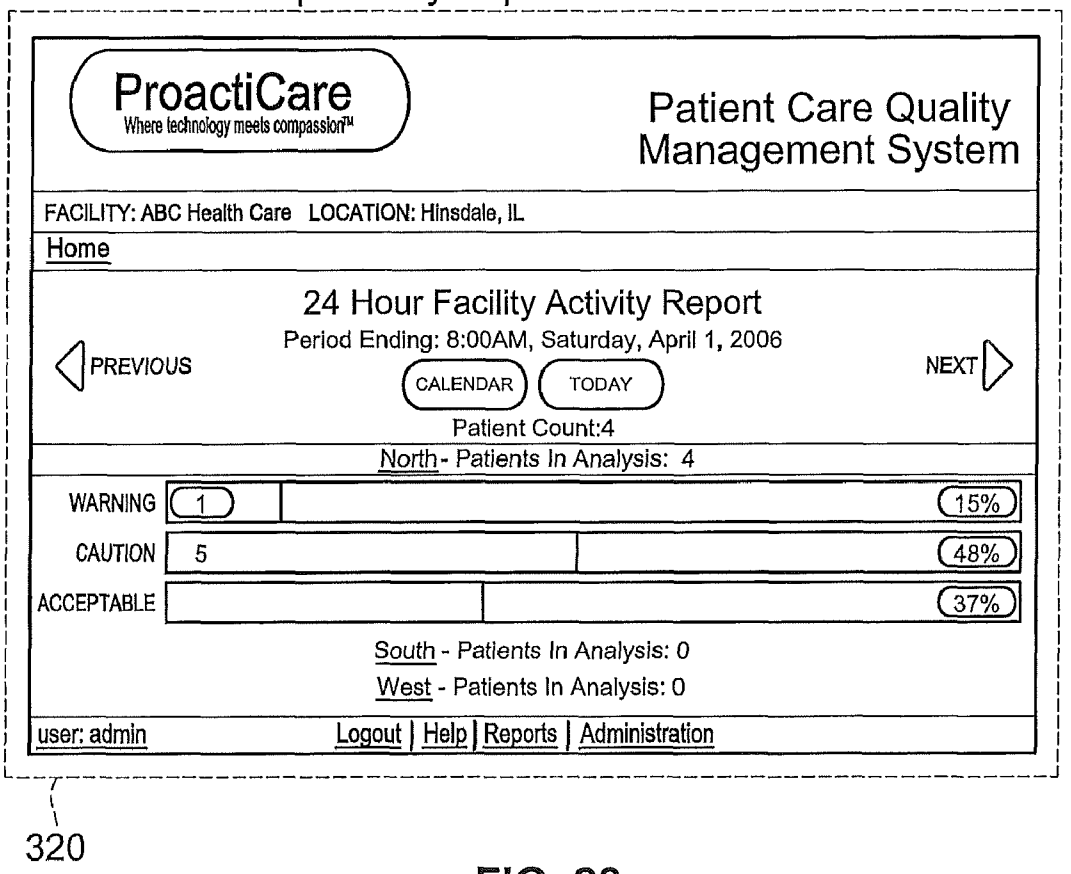


FIG. 22
Amended

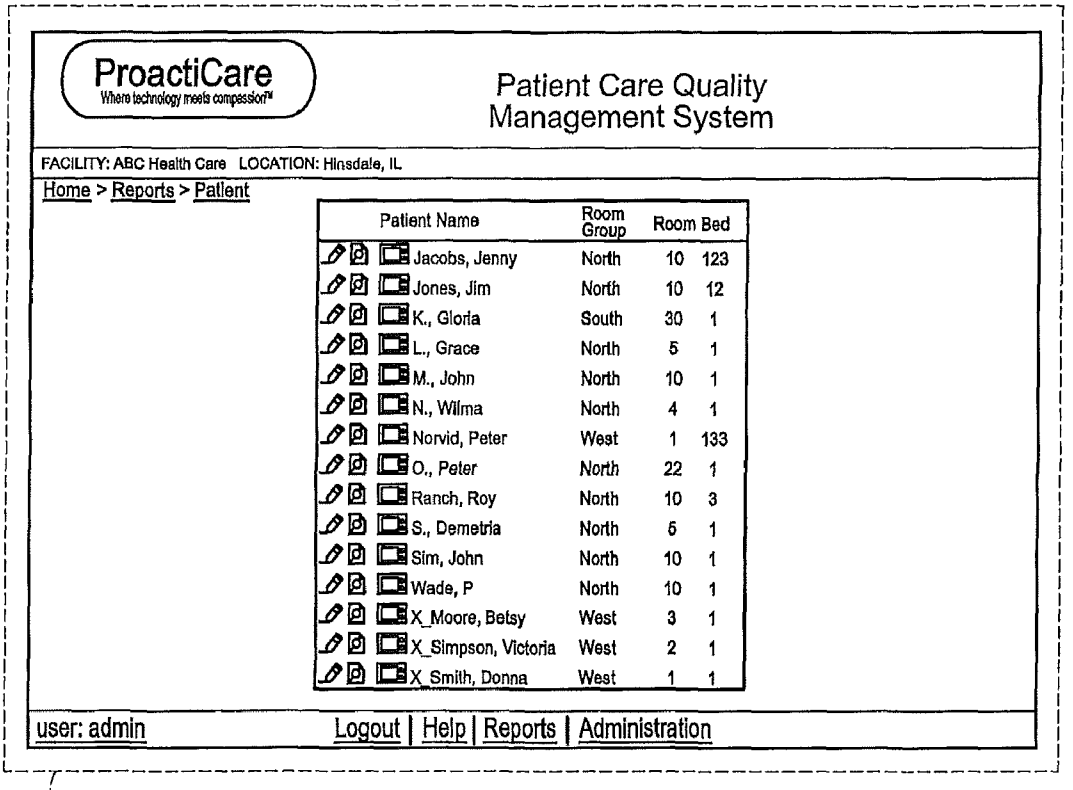
1120 Room Group Activity Report



320

FIG. 23
Amended

1310 Patient Status Report



330

FIG. 24
Amended

1320 Monitor Status Form

ProactiCare
Where technology meets compassion™

Patient Care Quality Management System

FACILITY: ABC Health Care LOCATION: Hinsdale, IL

Home > Reports > Patient Monitoring Reports

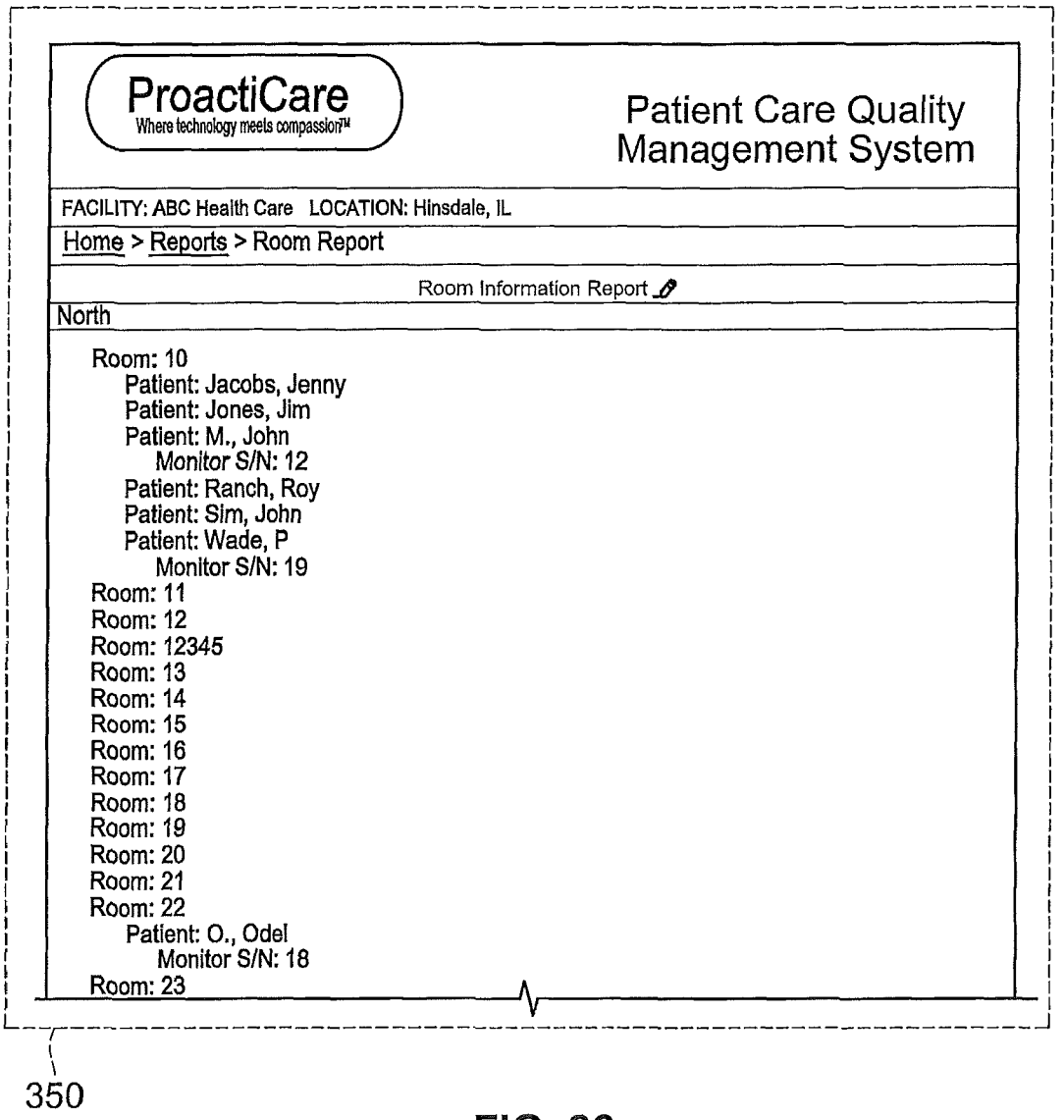
Patient Name	Room Group	Room	Bed	Caution Time (mins)	Warning Time Bed	Empty Level	Turn/Out Paging	Monitoring
Jacobs, Jenny	North	10	123	120	150	4500	○ ○ 18:00 - 08:00	●
Jones, Jim	North	10	12	120	150	4500	○ ● 00:00 - 24:00	●
K., Gloria	South	30	1	120	150	4700	● ●	○
L., Grace	North	5	1	120	150	4200	● ●	○
M., John	North	10	1	120	150	4000	● ●	●
N., Wilma	North	4	1	120	150	5000	● ●	●
Norvid, Peter	West	1	133	2	10	4300	○ ○ 00:00 - 24:00	○
O., Peter	North	22	1	120	150	4500	● ●	●
Ranch, Roy	North	10	3	120	150	4500	○ ○ 18:00 - 08:00	●
S., Demetria	North	5	1	120	150	4700	● ●	●
Sim, John	North	10	1	120	150	4500	○ ○ 00:00 - 24:00	●
Wade, P	North	10	1	2	4	5500	○ ○ 00:00 - 24:00	○
X_Moore, Betsy	West	3	1	120	150	4500	● ●	●
X_Simpson, Victoria	West	2	1	120	150	4500	● ●	●
X_Smith, Donna	West	1	1	120	150	4500	● ●	●

user: admin Logout | Help | Reports | Administration

340

FIG. 25
Amended

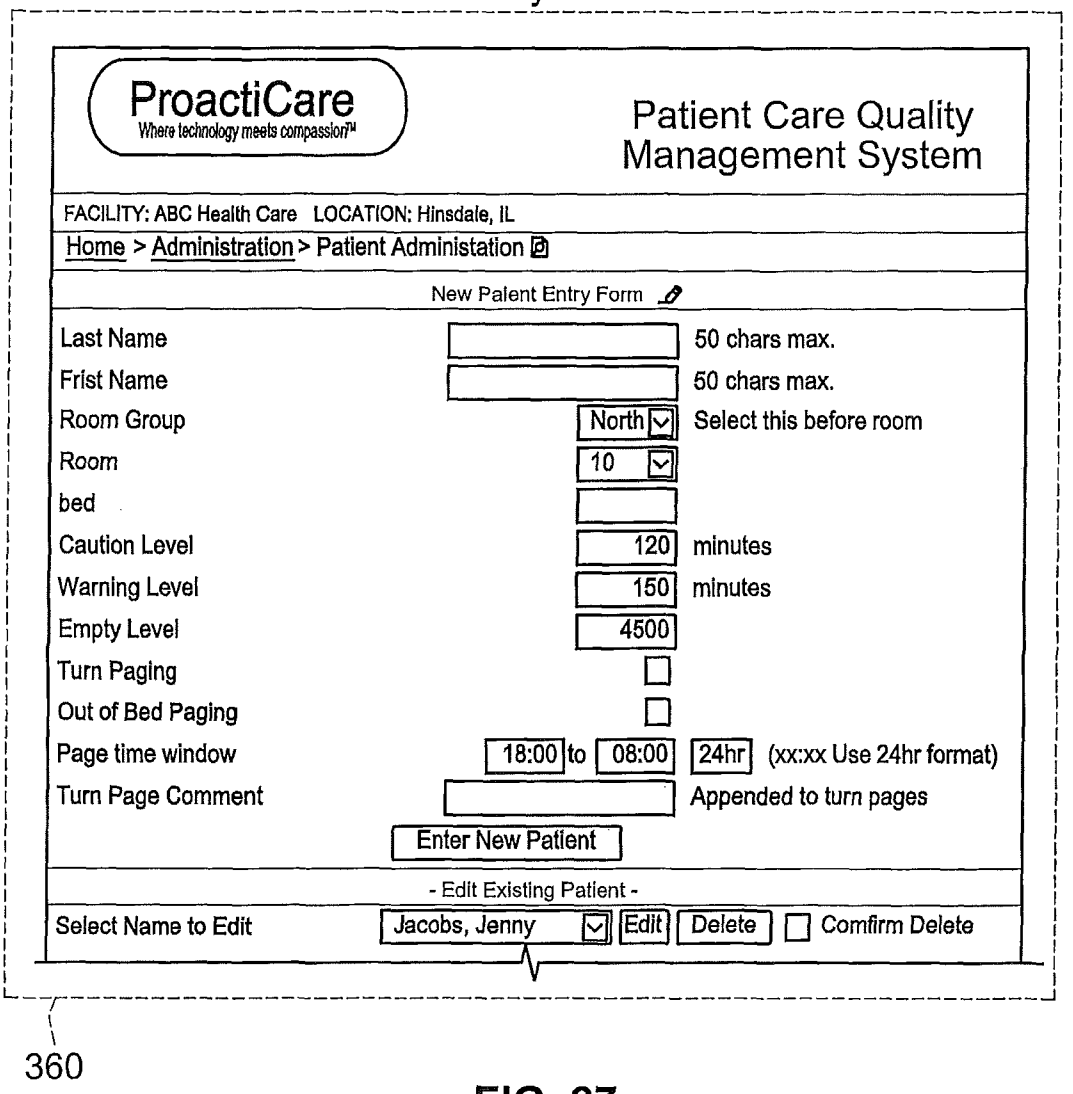
1330 Room Status Form



350

FIG. 26
Amended

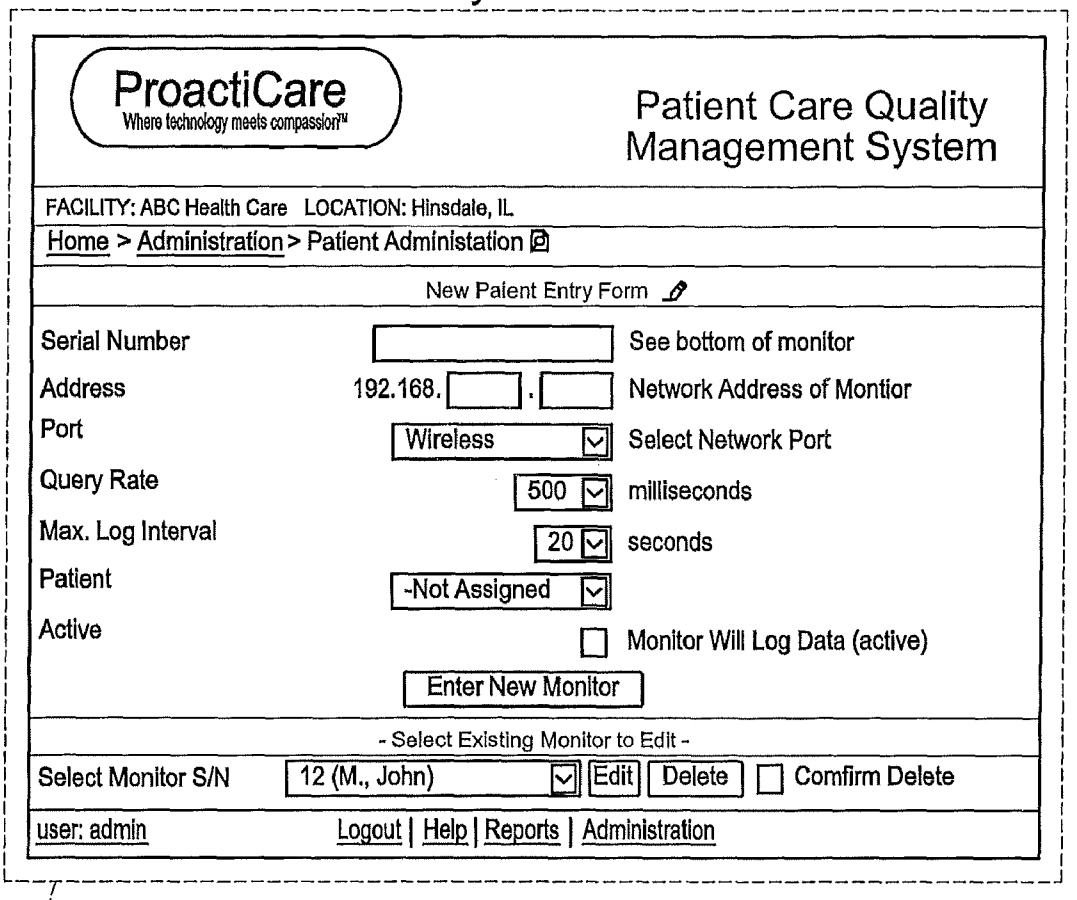
1410 Patient Administration Entry Form



360

FIG. 27
Amended

1510 New Bed Monitor Entry Form



370

FIG. 28
Amended

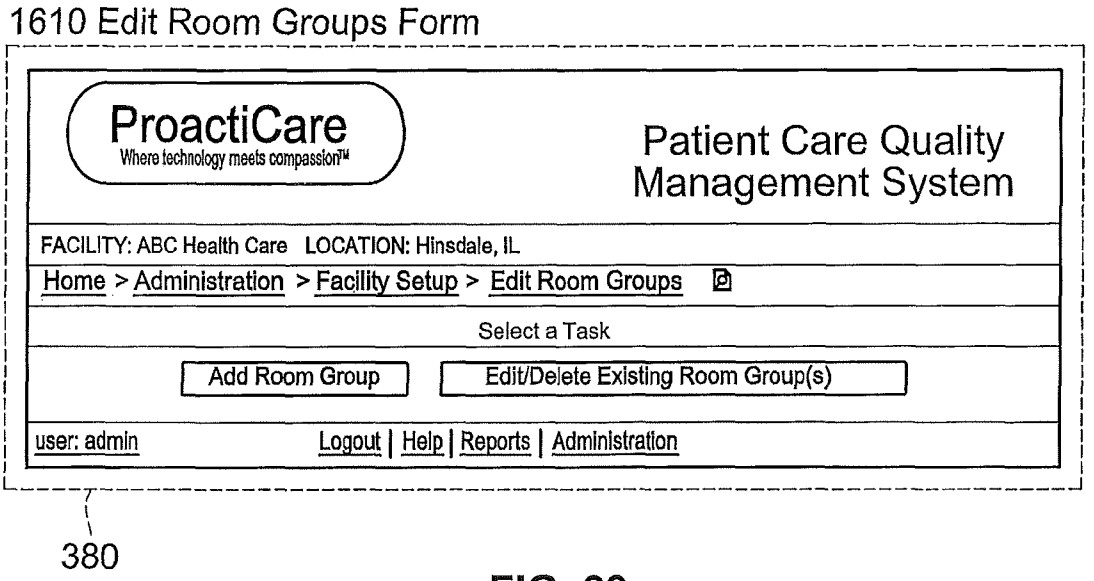


FIG. 29
Amended

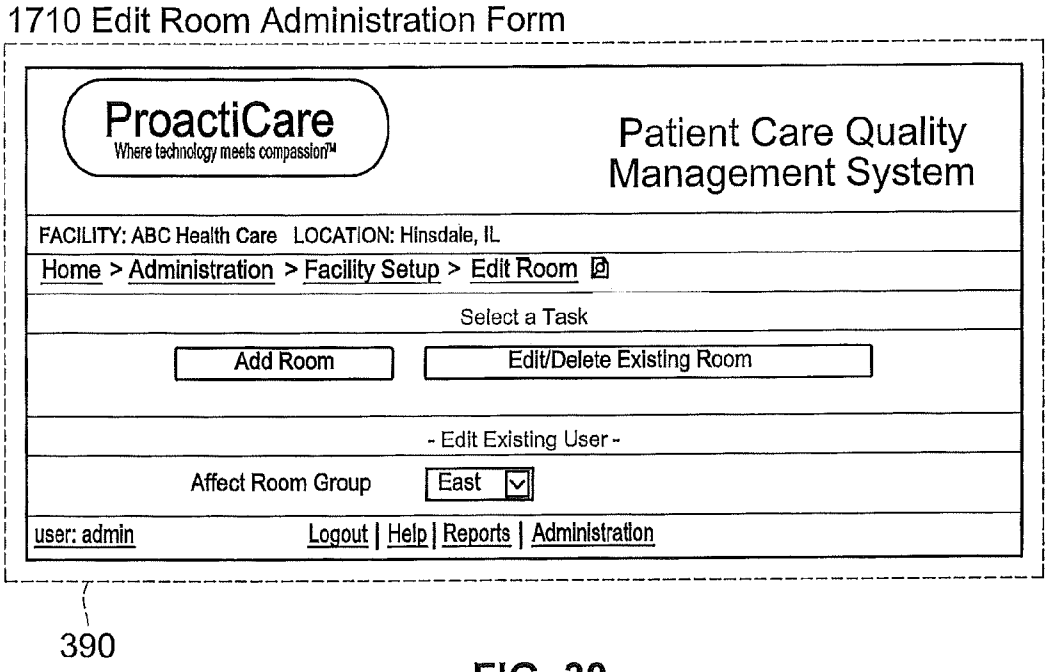


FIG. 30
Amended

SYSTEM AND METHODS FOR MONITORING CAREGIVER PERFORMANCE

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

FIELD OF THE INVENTION

The present invention relates to systems and methods for monitoring subjects, such as human subjects. More particularly, the present invention relates to systems and methods for monitoring and reporting caregiver performance in a healthcare setting related to care of a subject on a subject support device, such as on a hospital bed or nursing home bed.

BACKGROUND OF THE INVENTION

Many subjects in nursing homes may not have the physical capability to turn or reposition themselves in a bed and in such a case, depend upon staff members, typically a Certified Nursing Assistant (CNA) or other caregiver, to move them. This scenario may also occur in a hospital or similar setting. In many instances it is a requirement or medical necessity that the subject be turned in bed frequently at a specified interval, such as for example, every two hours, to prevent the development of tissue or skin breakdown, which can severely compromise health, comfort, and quality of life. Failure to periodically move the subject can result in what is commonly known as pressure sores or "bedsores".

What is needed is a system and method that can monitor the movement of a subject, patient or resident, (hereinafter referred to simply as "subject") so that movement of the subject can be detected, tracked, recorded and reported. Accordingly, systems have become available which alert a caregiver when a subject has moved or left the bed. Some of these systems have sophisticated means of determining the position of the subject on the bed. As used herein, the terms "CNA" and "caregiver" are used interchangeably and refer to a person providing care to an individual subject or subjects. Such a system and method may be used to monitor when a subject leaves and returns to the bed and detect and monitor patterns of movement. In many cases, subjects are unable to stand or walk from their bed unaided; however, these subjects attempt to exit their bed in a weakened condition and are at risk of falling and associated injuries. The system has the inherent ability to provide a signal when a subject has exited their bed and will notify the responsible caregiver of this situation.

These systems do not have a means to allow nursing home administrators, hospital supervisors or healthcare managers (hereinafter referred to as "clients") to confirm that a CNA or the like has performed his or her duty to move the monitored subject. The present invention addresses this need.

SUMMARY OF THE INVENTION

The present invention is directed to systems and methods for monitoring the performance of a caregiver. Simultaneously, the present invention is directed to systems and methods for monitoring the movement of each subject in a network of subjects and the response of the caregiver.

One system is shown to include a plurality of sensors, preferably in the form of strips disposed in spaced-apart relation to a mattress pad. The strips extend longitudinally from the head end of the mattress pad. The mattress pad is configured to be placed on top of a mattress, and to then be covered by a standard nylon slip-cover or the like that fits over the mattress and the mattress pad.

All software aspects of the invention have been written to be portable to multiple operating systems and hardware platforms. Open source applications and development tools have been used to limit downstream system, licensing and development costs. Web browser based data entry and reporting systems have been used to reduce client costs and allow users to interact with the system on familiar interfaces and hardware. It also allows handheld devices, pagers, cell phones, tablet PCs, etc. to be used without additional software development costs. Raw data is always stored so future enhanced data analysis tools have access to the original data. Multiple levels of security are used to protect the integrity and confidentiality of the data.

This system may include hardware and functionality in order to function as a bedside based undergarment moisture detector. In such a case, transmission of moisture data from patient undergarment to bedside would be performed via Wireless link such as RFID, ZigBee™, IR, Bluetooth™, etc. A small probe, such as a very thin wire is penetrated through the outer plastic surface into absorbency material. The probe could be designed to penetrate the backside of undergarment and be positioned where it could detect moisture. A very thin wire could run from the sensor to a small transmitter which would be attached to the front undergarment waistline of the subject. This front side transmitter could be a low cost, high efficiency, reusable transmitter which would enable data to be transmitted area wide or to the bedside DCT. At a predetermined value, the CNA could be notified that the subject was in need of an undergarment change. The major advantage that the CNA would no longer need to perform periodic checks, but only when specifically needed.

A nurse call module is provided and is adapted to be used as a device able to detect when a nurse call is placed on a conventional system and when it is answered. As the call is placed, the inline module detects a nurse call signal and then independently sends this signal back to the bedside DCT which then transmits it to the central processor where it is time and date stamped, and then incorporated into the database relative to the patient and/or DCT ID. In addition to the conventional audio and visual signals generated during a nurse call, the system also pages, emails or notifies via mobile phone that a subject is in need of assistance. Once the care has been rendered, the CNA would switch off the bedside nurse call device which would also signal the spy device to stamp the database with a time and date. The proposed device would be an in-line component which would be "jacked" into the wall and then the nurse call connector would be snapped into this device. The spy device could communicate to the DCT or other type of bedside transmitter via a hard wire or wireless connection. The major advantage of the system of the present invention is that the existing nurse call system would perform as intended, with the added advantage of verifiable care giver performance response time, thus allowing a better method of caregiver quality control.

A proposed system could also act as a bed alarm, monitoring when the bed is occupied or when it is empty, thus allowing the caregiver to be notified when a high risk "fall" subject is out of bed and in danger of falling while unattended. This warning system could be linked to the existing in-house audio and visual indicators as well as nurse station computer screen notification in addition to mobile phone, pager and other communication systems.

The DCT has an excess of bandwidth in both its wireless and hardwired configurations. This additional capacity combined with its current function as a bedside data collection and transmission device provides tremendous opportunities for additional in-room capabilities. Some of these concepts include voice, data and video communication, including a room call and patient audio and video monitoring. Other capabilities include high bandwidth devices such as sensors or monitors plus in-room internet connectivity.

Additional features of the invention will become apparent to those skilled in the art upon consideration of the following detailed description of preferred embodiments exemplifying the best mode of carrying out the invention as presently perceived.

BRIEF DESCRIPTION OF THE DRAWINGS

A detailed description particularly refers to the accompanying figures in which:

FIG. **1** is a schematic view of the monitoring system;

FIG. **2** is a cutaway perspective view of the head end of a mattress pad with sensors according to an embodiment of the invention;

FIG. **3** is a top plan view of the mattress pad and sensors;

FIG. **4** is an elevation view of the mattress pad;

FIG. **5** is a top plan view of a mattress pad and sensors covered by a mattress cover according to another embodiment of the present invention;

FIG. **6** is an elevation view of the mattress pad of FIG. **5** and a mattress, both of which are covered by a mattress cover;

FIG. **7** is a cutaway view of part of FIG. **5**, showing the mattress, mattress pad, and fastener, all of which are covered by the mattress cover;

FIGS. **8-12** each show a subset of operational steps of a data collector transmitter and the software therefor according to a method of operation of the present invention;

FIGS. **13-20** each show a subset of operational steps of the data server software according to a method of operation of the present invention;

FIG. **21** shows a "Home Page" according to an embodiment of the present invention;

FIG. **22** shows a "24 Hour Facility Activity Report Page" according to an embodiment of the present invention;

FIG. **23** shows a "View Room Groups Page" according to an embodiment of the present invention;

FIG. **24** shows a "Patient Reports Page" according to an embodiment of the present invention;

FIG. **25** shows a "Monitor Reports Page" according to an embodiment of the present invention;

FIG. **26** shows a "Room Status Reports Page" according to an embodiment of the present invention;

FIG. **27** shows a "Patient Administration Entry Form Page" according to an embodiment of the present invention;

FIG. **28** shows a "New Bed Monitor Entry Form Page" according to an embodiment of the present invention;

FIG. **29** shows an "Edit Room Groups Form Page" according to an embodiment of the present invention; and

FIG. **30** shows an "Edit Room Administration Page" according to an embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

A system **31** for monitoring the performance of a caregiver relative to movement of a single subject **32** or a plurality of subjects **32** is shown in FIG. **1**. Illustratively, subject **32** is positioned on a bed **34**, but it should be understood that other subject support devices, such as chairs, wheelchairs, or the like, are within the scope of the invention. Accordingly, all of the attributes of the system *31* described herein can be applied to any type of subject support device.

As shown in FIG. **1**, system **31** includes a plurality of beds **34**, each having a sensor **36** that is in communication with a central processor **38**, such as that which can be found in the computer shown in FIG. **1**. The sensor **36** may be a single sensor or preferably a sensor array including a plurality of individual or separate sensor units. The central processor **38** may take the form of other computing devices having the capability of detecting changes in the status of sensors **36** and outputting an alarm, notice or report, for example. The system **31** preferably uses a web browser based reporting system. Reports are generated on a web server (not shown) and viewed on standard web browsers with no special software required. The data is presented in a hierarchical fashion giving a quick overview as well as the ability to drill down to the lowest level of interest. The reporting system is designed to quickly identify areas of the facility that may need attention. Other functions—*such as a data gathering device*—of the central processor **38** will be explained in more detail below.

The sensors **36** may include electrically conductive strips, which when they are brought into proximity or are permitted to disconnect, undergo a change of state with respect to, for example, opening or closing a circuit.

Other sensors are also contemplated that are capable of sensing a change of position or status of a subject, such as pressure sensors, heat sensors, and so on. The sensors **36** may include conductive material, such as conductive paint, plastic, metal or any other material that when triggered functions to register or detect a change of status of a subject operatively associated with the sensor and generate or permit the generation of a signal or event therefor.

Sensors **36** may communicate with processor **38** via a wireless (WiFi) connection, using wireless transmitters **40** that communicate with a base station **42** that is connected with processor **38**. The transmitters, both shown at **40** and **46**, and based on a Motorola IC, part no. 33794, are also known as a data collector transmitter (DCT), which is a slave device that transmits data to a master device **38** using a predefined protocol. The protocol is designed to be compatible with a wide range of networks including, but not limited to RS232, multi-drop RS485 as well as higher level networks such as Ethernet, Bluetooth™, ZigBee™, 802.15.4 and WiFi. Addressing and error detection is provided at the lowest level of the protocol for use on simple RS485 type networks.

The data gathering master device *of the central processor* **38** is used to collect data from the slave DCT units **40**, **46**. The *master* device **38** requests data from each DCT **40**, **46** at the desired data rate. Preferably, the data gathering master device **38** is a networked PC running applications designed to communicate with as many as several hundred DTC units **40**, **46** at the same time. It is a multi-threaded, object oriented, fault tolerant program that can recover from network and DCT **40**, **46** problems in real time without affecting data gathering on the rest of the system **31**. The device **38** may store all data into a standard SQL relational database **39**.

The master device **38** may be a standard PC running a Java application. The program reads and writes to a database **39**. The device **38** uses conventional programming to interface with the database **39**, so portability to other databases is possible. The device **38** polls the database **39** at regular intervals to determine the number of clients (DCT units or installations) it needs to communicate with. Each DCT device **40**, **46** has a unique address and communication rate stored in the database **39**. The device and the applications running thereon

are multi-threaded so problems with individual devices and network latency do not affect other devices and program performance. If one slave device **40**, **46** is not responding, all other devices will still return data at the predetermined rate. The device **38** will continue to try to regain communication with the non-responsive slave until it is successful or the entry in the database is removed. The data received from the slave devices **40**, **46** is stored in the database **39**. The data is time stamped and referenced to the slave device **40**, **46**. To reduce the database growth, if there is no movement by the subject, or if the subject is no longer in bed, the recorded sensor values will be at wider intervals. However, once movement is again detected, the system will be triggered to begin collecting data at a more rapid and predetermined pace allowing full resolution of the subject movement. Even if the minimum change amount has not occurred, data will at least be stored at a predetermined interval such as once every 10 seconds, for example, or at any suitable interval. The master device **38** is intended to run autonomously.

The sensor **[**pad**]** **36** is connected to the DCT **46**, which includes a microcontroller. The microcontroller has custom software written in the C programming language. The microcontroller constantly polls the sensor *36* looping between the 9 electrodes of the sensor **36** using one of several built in 10-bit analog to digital channels. The microcontroller can calibrate the system to adjust the output of the electrodes so they all read roughly the same value when no subject **32** is in the bed **34**. It can also adjust the high and low end points of the sensor values to use the full 10-bit range. The calibration values are stored in non-volatile EEPROM so they are not lost if the power is interrupted or removed. The read values are adjusted by the stored calibration and stored in RAM. The values in RAM are then used to quickly respond to the master device when requested.

All communication is done with the microcontroller using a serial data protocol. The protocol uses an 8-bit address and a 16-bit CRC to insure data integrity. While the address and CRC are not needed with higher-level networks like Ethernet, they allow the use of future, simpler networks like RS485. The DCT **40**, **46** currently uses an OEM serial to Ethernet device (not shown), but another embodiment includes integration into the microcontroller.

Although wireless transmitters **40** are shown in FIG. **1** to be separate from sensors **36**, and connected with a **[**wire**]** *harness* **44**, it is within the scope of the invention to combine the wireless transmitter **40** with the sensor or to place it in other locations, such as within a bed mattress. Wireless transmitters **40** are illustratively capable of collecting data from **[**its**]** *their* associated **[**sensor**]** *sensors* **36**. The system **31** is preferably configured so as to be capable of handling upwards of a hundred beds or more that may comprise a hospital network or a nursing home network, for example.

As an alternative, a transmitter **46** may be used, the transmitter **46** having a wired (e.g., Ethernet) connection with processor **38**. Illustratively, transmitter **46** uses an Ethernet network consisting of Ethernet cables **48** and an Ethernet hub **50** that is in communication with processor **38**. Of course, system **31** may include both wireless and Ethernet elements, and may be connected via other means and/or protocols, such as coaxial cable, electrical wires, radio frequency, Bluetooth™, ZigBee™, 802.15.4 or any other manner for communicating data that is known in the art.

As can be seen in FIGS. **2-7**, sensor **36** comprises a mattress pad **54** having an array of parallel conductive fabric strips **58** adhered thereto. Strips **58** extend longitudinally along the mattress pad **54**, starting at the head end **60**. A fastener **52** may be coupled to one end of each of the strips **58** at the head end **60** of the mattress pad **54**. While the illustrated embodiment contemplates the adhesion of the strips **58** to an upper surface *or top side* **64** of the mattress pad **54**, it should be understood that other configurations and fastening methods are within the scope of the invention, including the placement of the strips **58** within the pad **54**, or on top of another surface such as directly on top of a mattress **56**.

In the illustrated embodiment, strips **58** are evenly spaced at an interval A (shown in FIG. **3**), such as four inches. Strips **58** are illustratively width B, which is approximately one inch in the presently shown embodiment.

Mattress pad **54** is illustratively a half-inch thick urethane foam pad that is cut to the same dimensions as a mattress **56** on which it is to be positioned. Such urethane foam is flame retardant, thereby meeting the FF 4-72 (cigarette test) standards for flammability set forth by the Consumer Product Safety Commission. Furthermore, the foam preferably conforms to the California Technical Information Bulletin No. 117 regarding combustibility.

In the illustrated embodiment, nine strips **58** are positioned in parallel orientation to run longitudinally from the head end **60** of mattress pad **54**. Each of the strips has an adhesive bottom surface (not shown) that is configured to adhere to the mattress pad **54**. The adhesive surface is illustratively a pressure sensitive adhesive (PSA), however, other adhesives are within the scope of this invention. After each of the strips **58** is adhered to a top side **64** of the mattress pad **54**, the entire mattress pad is overlaid with a flame retardant polyester cloth **55**, (FIG. **7**) thereby capturing the strips **58** and functioning so that the strips remain securely in place throughout the life of the mattress pad *54*.

Strips **58** may be any suitable thickness, such as approximately 0.008 inches thick and made of a conductive laminated fabric. The laminated fabric is flame retardant with a UL 94 V-0 rating. One example of such a fabric is manufactured by Laird Technologies of St. Louis, Mo.

As can best be seen in FIGS. **5-7**, which shows another embodiment of a portion of the present invention, an outer mattress cover **62** is positioned over mattress **56** and overlying mattress pad **54** so that the entire sensor **36** is removed from direct contact with sheets or a subject. Mattress cover **62** is preferably a standard nylon covering used over a standard nursing home mattress.

As can be seen in FIGS. **2**, **3**, and **7**, a fastener **52** is pressed into each of the strips **58**, providing an electrical connection therewith. Fastener **52** may be a male metallic snap fastener that functions as the connection point between the conductive fabric *strips 58* and a connector harness **44**.

The connector harness **44** links the array of strips **58** to either a wireless transmitter **40** or a standard, wired transmitter **46** (FIG. **1**). As mentioned above, the transmitter **40**, **46** functions as a data collector and a transmitter of such data. In one embodiment, the harness **44** may include nine coaxial conductors approximately 30 inches in length. Each of the individual coaxial conductors is approximately ⅛ inch in diameter. At the end proximal to the mattress pad **[34]** *54*, each of the coaxial connectors is terminated by a ⅛ inch crimp-on ring terminal, which allows simple and secure attachment to the array of strips utilizing the female snap ring to capture the ring connector (not shown).

The end (not shown) of the harness **44** which attaches to the transmitter **40**, **46** may include a D-Sub 15-pin male connector. Each of the nine coaxial center leads (not shown) may be individually crimped into a connector pin and inserted into locations within the connector back shell. Each of the nine outer shields from each coaxial conductor may be soldered with a "drain wire" or alternately, stripped and combined into

a single termination which may be soldered together to ensure proper termination, and covered with a heat-shrink insulator. All nine drain wires may then be combined into a single conductor and crimped into the conductor as a tenth pin connector. Through the use of coaxial conductors, signal integrity to and from the array of strips **58** tend to be consistent and reliable during operation.

The back shell (not shown) also permits the ability to monitor and verify whether the connector is securely attached to the transmitter **40**, **46**. A wire loop (not shown) can be configured to connect to two specific pins within the back shell. Alternately, a single wire may be used with the actual metallic back shell, used as the other conductor, and acting as a complete circuit when connected. When the wire completes the simple circuit within the transmitter **40**, **46**, the electronic circuitry will indicate that all systems are functional. Should the connector unfasten from the back of the transmitter **40**, **46** the circuit will be broken, which will immediately flag the system **31**, advising that the connection between the array of strips **58** and the transmitter **40** (or **46**) has been broken.

The transmitters **40**, **46** utilize E-field sensing technology combined with a programmable microcontroller that acts as the computing portion of system **31**. The transmitter **40**, **46** performs multiple functions by communicating with the array of sensors **36** and then transmitting this information to a remote database **39** (FIG. **1**) for interpretation and review. The database **39** stores data for the facility, room groupings (wings, floor, building, etc.), rooms, and subjects **32**. The database **39** also stores addressing and configuration information for the DCT units **40**, **46**. Finally, the database **39** also stores all of the logged information from the DCT units **40**, **46**.

The database **39** also stores other data related to the installation facility. This allows data to be correlated to the facility, facility zones, caregivers and subjects. The facility information is entered into the system **31** using a web browser. The interface is designed to allow very efficient data entry.

Each DCT **40**, **46** generate a unique e-field to each of the nine strips **58** within the array of strips. As each of these strips **58** are energized with a very low e-field, within milliseconds, a unique signal is returned relative to the size and position of the subject **32** above the strip **58**. In the present embodiment, this is performed continuously across all nine strips **58**, taking full positional information twice every second. Any change in the position of the subject **32** generates a change in the electrical field of the array of strips **58**. Other schemes are also contemplated, such that sufficient information is collected to detect movement of the subject **32**.

Once a transmitter **40**, **46** has received the information from the array of strips **58**, the information is converted into a digital code and sent via network to an onsite computer **38** (FIG. **1**) for inclusion into a database **39** (FIG. **1**) correlated to specific bed information, along with a time and date stamp. The transmitter **40**, **46** is designed to be flexible in its data transmission mode and can be utilized in a hard wired or wireless network mode, as disclosed above.

Each transmitter **40**, **46** can be powered by a 12-volt wall-mounted power supply capable of a maximum 500 milliamp current draw. Alternately, it is envisioned that an internal power source could be utilized in lieu of an external power source. Examples include lead acid, NiMH, and fuel cell type power sources. The transmitter **40**, **46** also incorporates a solid state, resettable fuse insuring that the current will be cut off should there be any reason that current is drawn above the required power draw for the device. The housing for the transmitter may be formed by injection molding with ABS plastic having a flame retardant rating of UL94 V0.

Ethernet hub **50** can be a standard 10/100 hub that can be found at any computer or electronic store. Base station **42** can also be a standard wireless/hard-wired base station that can communicate, for example, over the 802.11 standard for wireless communications. It should be understood, however, that other configurations are within the scope of the invention, for example, base station **42** and Ethernet hub **50** could be combined into one device. System **31** can be configured to notify selected persons, i.e. nursing home or hospital management, via pagers **53**, cell phones **51**, e-mail **49**, (see FIG. **1**), fax, etc. through an Internet connection **47**, wired or wireless or any suitable communication means or method.

System **31** can also be connected to the Internet **47** (FIG. **1**) to permit remote access via either an in-house web page or a secure connection utilizing a standard web browser. The client interface may be entirely web browser based. The web pages may be served from a Windows Internet Information Server (IIS) using the PHP scripting language. The clients can see the data as pure standards based HTML without any special applications or plug-ins required. This allows any browser and operating system to access the system. Varying levels of access can be granted for access to the data stored by the system **31**.

A software program manages the microcontroller, providing control of the E-field. It also routes the data out of the transmitter **40**, **46** and into the network.

The processor **38** functions in at least two capacities: data gathering **[**and incorporation**]** into a database **39** (FIG. **1**) stored in or in communication with processor **38**, and data interpretation and report generation. The database **39** can track the data from each of the transmitters **40**, **46** on a continuous basis. In the present embodiment, information from each strip **[38]***58* in the array of strips is stored and time stamped twice every second. The database **39** then stores the information and can group the information, for example, to track: (a) unique bed, floor/wing, and facility information relative to a caregivers responsibility (b) individual subject position data as a function of time (c) transmitter information relating to IT addresses and other hardware characteristics and (d) facility names and other identifiable characteristics.

The database **39** stores data from each transmitter **40**, **46**, which can be time-stamped for analysis and interpretation. Through the use of data analysis processes executed by software (detailed below) meaningful indicators can be established to confirm caregiver activity and the associated subject movement relative to specified medical orders. The output data may be selectable so as to provide a morning report giving a brief overview of caregiver performance on targeted subject rotations. Additionally, weekly and monthly performance reports may be created and can again be arranged by a particular caregiver.

In operation, the system **31** may be used as follows. A facility manager may review a status report displayed on or printed through processor **38** upon his/her arrival at the beginning of the shift. Such a status report could show the performance of caregivers on the prior shift, as well as any movement of the subject **32**. The report could correlate movement or caregiver-initiated movement with that ordered by a physician. Other reports may be executed that show movement over a longer period of time, or even that show performance of a particular caregiver over a period of time. Results could also be color coded, could be arranged by building wings or groups of rooms, or arranged in any other manner that is intuitive or preferred to the management. Information could be password protected in order to prevent the breach of security.

It is an advantage of the system **31** that no direct subject contact need occur and the system is nearly completely out of sight from the subject **32**. In the event that the system **31** is disabled or switched off, no adverse side effects will occur since the system is not attached to the subject *32*. Furthermore, the immediate health of the subject *32* is not dependent upon the operation of the system **31**.

FIG. **8** shows the initialization sequence of the data collector transmitter (DCT). The DCT is powered on **102**. The hardware portion of the DCT is initialized **104** and an indicator, such as an LED is used to indicate start-up, preferably by blinking on and off or by displaying a predetermined first color **106**. Interrupts and timers are enabled **108**. Configuration and calibration data is read **110**, preferably off of a non-volatile device, such as non-volatile EEPROM. Variables are initialized and the first sensor is selected **112**. The program then enters an infinite loop of reading the sensors in sequential order. The process waits a predetermined amount of time while the sensor settles **114**. At step **116**, the DCT begins to read the sensor. The microprocessor will generate an interrupt when the analog to digital conversion is complete. Before the process loops back to step **114**, it checks to see if a completed calibration needs to be saved **118**. *If necessary, calibration is saved at step 120.* When an analog to digital conversion completes, an interrupt occurs *at step 162* (FIG. **12**) and the value is saved to RAM **164**. At this time, calibration calculation and/or digital filtering may occur, depending on the current mode of operation. The current sensor number is then indexed **166** to the next number **[**or returns to the first number if the highest numbered sensor was just read **168.]** *The sensor index is compared to the maximum sensor index 168. If the sensor index is greater than the maximum sensor index the sensor index is set to the sensor minimum 170. The interrupt exits at step 172.*

The serial data receive process is also interrupt based (FIG. **9**). An interrupt is generated for each character received *122*. A communication timer is restarted **124**. *The buffer index is incremeneted 126 and a character is gotten 128. The character is analyzed to determine if it is the first byte 130. If it is, the character is subsequently analyzed to determine if it is the header byte 132, if it is the header byte the interrupt exits 136. If at step 132 the character is determined not to be the header byte the buffer index is reset to zero 134 and the interrupt handler exits 136. More specifically, the timer interrupt occurs 156* after the receipt of each character to clear the buffer *158* if partial messages or erroneous data are received (FIG. **11**). **[**Each character is analyzed in sequence to determine when a full message is received **130-146**. A CRC (Cyclic Redundancy Check) is then calculated **142** and checked for errors against the message for errors. If anything is wrong with the message, the buffer is cleared **134** and the DCT waits for the next message. If the message is valid, the DCT responds with data and actions are taken. Modes are set as required **144.]** *The interrupt exits at step 160.*

Going back to step 130 if the character is determined not to be the first byte, a determination of whether the index is greater than the length character and whether all the characters are present is made 138. If the determination at step 130 is answered in the affirmative, the process proceeds to step 142; if not the process proceeds to step 140. At step 140 it is determined whether the buffer is full, if it is the buffer index is reset to zero 134 and the interrupt handler exits 136. If the buffer is not full the buffer index is incremented 146 and the interrupt handler exits 136. At step 142 it is determined whether the CRC (Cyclic Redundancy Check) is correct, if it is, the DCT processes the command and the response is returned 144 and the interrupt handler subsequently exits 136. If at step 142 the CRC is found not to be correct, the buffer index is reset to zero 134 and the interrupt handler exits 136.

A general purpose timer (FIG. **10**) also generates an interrupt on a periodic basis. On each of these interrupts *148*, the DCT does a general status check to determine if any problems have occurred; such as sensor cable disconnection *150* or other communications errors. The fault LED will toggle state **152** at this time if a fault exists. *If no problems have occurred the general purpose timer exits 154.*

FIG. **[12]** *13* shows the startup sequence of the data server. **[**The**]** *After startup 174, the* graphical interface is initialized *176*, and then a "collection" is created *178* to track the active slave devices (DCTs). A timer is started *179* that will periodically check the database to determine if new DCTs need to be added to the collection or if any need to be removed. *The program startup is complete at step 180.*

When the DCT check timer event occurs *at step 182*, (FIG. **14**) the active DCT list is read from the database. *Records of active DCTs are assembled into a recordset at step 84.* The program **[**loops**]** *iterates* through the records *at steps 186-192* to determine if any DCTs are new or need to be removed. *More specifically, a record in the recordset is selected at step 186. At step 188, it is determined whether a corresponding object exists for the record. If no such object exists one is created at step 190. Once an object exists for the record, it is determined whether there are any additional records at step 192. If there is at least one such additional record, the program returns to step 186. If no such additional records exist at step 192, objects corresponding to non-active DCTs are removed at step 194. The timer hander exists at 196.*

Each DCT is communicated with using its own program thread (FIG. **17**). This prevents problems with other DCTs from affecting communication with other DCTs. At the creation of each thread *206*, a log interval timer is set up **208**. A network connection is then attempted to be established **210**. This will loop forever until a connection is established *212* or the thread is terminated. The main server thread is informed of the current connection status of each thread **214**, **216**. If a connection is established, the log interval timer is then started **218** *and the process exits 220.*

When a log timer event occurs **222**, a message is sent *224* to the DCT requesting current sensor values *as shown in FIG. 18.* The thread will then wait until the data received event occurs *at step 242* (FIG. **20**). The message will be verified for integrity **244**. *If integrity is not present, the response is ignored 246.* Valid data messages will generate an event **250** for the main server thread (FIG. **15**).

When DCT data received events occur *at step 198*, (FIG. **15**) the server stores the data in the database, time stamped and tagged to the patient **200**. When DCT threads detect a change in status of the DCT *202*, it will generate a status change event *204* (*FIG. 16*). When these events occur, the main server thread updates the interface and writes to the database.

Shown in FIG. 19, when a status-change event occurs, the event handler starts at 228. Once started, the event handler sends the event and its status to the parent 230. The event handler then exits at 240.

The system **31** user software is preferably designed to operate as a web based system with the functionality of being easily accessed on-site or from a remote location using a standard web browser, e.g., Microsoft Internet Explorer™ or an equivalent thereof. The browser enabled interface (see FIG. **21**) is designed to operate independently from all other software elements within the system **31**, including the "bed logs" database **39** and data collection *from sensors* **36**, *and*

DCTs **40**, *46* portions of the overall system. The "Home Page" **[100]** *300*, shown in FIG. **21**, is also the main screen which all users will first encounter when interfacing with the system **31**.

The home page **[100]** *300* is broken out into two main sections, a report generating portion **[102]** *302* and administrative portion **[104]** *304* including patient, monitor and room information. All of these individual sections may be password protected depending on the pre-determined authorization of the end-user. At any time within the various sub-menus, the logo **[106]** *306* may be clicked which will take the user back to the home page **[100]** *300*.

An objective of the system **31** is to insure that while a patient is under the care of a healthcare professional; all rotations are performed at the specified intervals as dictated by medical orders. The system **31** will continuously provide critical caregiver performance data detailing the type of movement performed and most importantly time and date of these interactions insuring that a formal record of performance is established.

The "24 Hour Facility Activity Report," **[110]** *310*, FIG. **22**, is intended to act as a quick facility scorecard, which will visually indicate overall performance of all assigned caregivers, relative to all rotations required throughout the entire facility duty shift. This record will be typically reviewed by a manager or supervisor at the end of a facility shift. Although the report described is based on a 24 hour duty cycle, additional reports will include other durations including real-time information, weekly or monthly performance indicators.

Three simple visual indicators **[112]** *312* will show green, yellow or red, for example, describing level of performance within the facility. If the indicator is green, this may confirm that all rotations within the facility were performed according to specified medical orders. If the indicator is yellow, this may mean "caution" which points to the fact that specific patients may not have been rotated as required by medical orders and/or at the specified times. Additional investigation may be required to determine what had transpired during the interval under question. The red indicator may specify that there may have been significant portions of the patient rotation regimen not completed. Near the bottom of the page **[114]** *314*, the end user can click on the "View Room Groups" to drill down further into caregiver performance data relative to individual caregivers on specific floors or facility wings.

The View Room Groups screen **[120]** *320* (FIG. **23**) is designed to show room groupings within a facility, which are typically tied to a specific caregiver during their duty shift. This information will allow facility management to determine which specific rooms, beds and the specific patients that were not rotated during a set period of time.

The Patient, Monitor and Room Status Reports, **[130]** *330*, **[140]** *340*, and **[150]** *350* (see FIGS. **24-26**) are displays which provide the accurate and up to date information for the system **31**. Patient Status Report **[130]** *330* provides the location of the patient by both room and overall grouping. This insures that the information to be also tied back to the specific caregivers' responsible for these specific room groupings. The Monitor Status Report **[140]** *340* advises which monitors are available for use within the facility and also which units are currently in service at the patient bedside. Additional information includes serial number, patient name that is tied to the DCT and IP address. Other information includes data collection intervals for each patient. The Room Status Report **[150]** *350* details patient name, Data Collector Transmitter (DCT) serial number, room number and overall room grouping.

The Patient Administration Entry Form **[160]** *360* (see FIG. **27**) provides a simple and effective method to enter patient data into the system records **39**. Additional information required includes Room Group, Room Number, turn frequency (default 120 minutes) and allowable turn window (e.g., 15 minutes). Ideally a patient should be rotated precisely at the prescribed turn frequency, for example every two hours, however, due to actual workload and other demands on caregiver time; they may not be able to rotate a patient at an exact time interval. The allowable turn window will provide an additional time range which allows the caregiver to perform a specified or required rotation within a pre-set time interval, for example 15 minutes beyond the two hour turn frequency. Should a patient remain unturned beyond the established turn window interval, the system will "flag" this record providing the manager with an indicator that the caregiver has missed a turn. The entry form also allows editing of the patient information in the event the patient changes rooms or leaves the facility.

The New Bed Monitor Entry Form **[170]** *370* (see FIG. **28**) is intended to allow facility managers to add new monitor devices to the facility. It also allows several selectable functions regarding data transmission via either hardwired or wireless link. Other features include assignable query rate, maximum log intervals, patient info and activation check box (turn on or turn off communication with DCT). This entry form also allows editing of existing monitor information.

The Edit Room Groups Form **[180]** *380* (see FIG. **29**) allows easy addition, modification or deletion of specific room groupings. Typically these room groups will be tied directly to specific caregiver room assignments within a facility, thus tying the assigned caregiver to their grouping of rooms. Once the room groups are set, only patient rooms falling within these groups will be in the dropdown menu. For example if there is a "South Room Group" only specific rooms that are pre-assigned during setup will be within the dropdown menu. Other rooms within the facility will be tied to their proper, pre-determined room group. In addition, a full report may be viewed detailing all room groups within a facility

The Edit Room Administration Form **[190]** *390* (see FIG. **30**) will allow a facility manager to add, modify or delete rooms within a specific room group. There is also a feature to view the specific rooms and how they relate to specific room groups.

Other features such as data export, import, analysis and graphic visualizations may be considered important in the expansion and enhancement of the system **31**.

While the disclosure is susceptible to various modifications and alternative forms, specific exemplary embodiments thereof have been shown by way of example in the drawings and have herein been described in detail. It should be understood, however, that there is no intent to limit the disclosure to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the appended claims.

There is a plurality of advantages of the present invention arising from the various features of the subject monitoring system and associated method described herein. It will be noted that alternative embodiments of the subject monitoring system and associated method of the present invention may not include all of the features described yet still benefit from at least some of the advantages of such features. Those of ordinary skill in the art may readily devise their own implementations of a subject monitoring system and associated method that incorporate one or more of the features of the present invention and fall within the spirit and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A system for monitoring performance of a caregiver, the system comprising:

a mattress pad;

an active capacitance sensor attached to said mattress pad, each said active capacitance sensor capable of sensing movement of a subject and capable of generating a signal resultant from the movement of the subject, wherein said sensor includes a plurality of fabric strips manufactured from a conductive material;

a processor in communication with said active capacitance sensor, said processor being provided with computer readable code for tracking information relative to the caregiver and generating a report related to the performance of the caregiver.

2. The system of claim **1**, further comprising a plurality of said mattress pads, each said mattress pad having one or more of said sensor attached thereto.

3. The system of claim **1**, wherein said sensor includes a plurality of sensors longitudinally adhered to said mattress pad in spaced apart intervals.

4. The system of claim **3**, further comprising a plurality of electrically conductive fasteners, each fastener engaging a respective one of said plurality of sensors.

5. The system of claim **1**, wherein said sensor is capable of detecting a change of orientation or position of the subject.

6. The system of claim **1**, wherein said mattress pad is a urethane foam pad.

7. The system of claim **1**, further comprising a transmitter for transmitting signals generated by said sensor and conveying said signals to said processor.

8. The system of claim **7**, wherein said transmitter is wireless.

9. The system of claim **7**, wherein said transmitter is further configured to collect signal data prior to transmitting said signal data.

10. A system for monitoring the performance of a caregiver, the system comprising:

a plurality of mattress pads;

a plurality of strips configured to adhere to each of said plurality of mattress pads, each of said plurality of strips comprises a conductive fabric material having an active capacitance electrical field sensitivity and capable of creating signals based on the electrical field sensed, wherein said electrical field sensed is directly received from a subject positioned on one of said plurality of mattress pads;

a plurality of transmitters, each of said plurality of transmitters being coupled with said plurality of strips adhered to one of said plurality of mattress pads; and

a processor in communication with said plurality of transmitters; said processor being provided with computer readable code for tracking information relative to the caregiver and generating a report related to the performance of the caregiver.

11. The system of claim **10**, wherein each of said strips is longitudinally adhered to each of said mattress pads in spaced apart intervals.

12. The system of claim **10**, wherein each of said strips extends from a head end of each of said mattress pads toward a longitudinally central portion of each of said mattress pads.

13. The system of claim **10**, wherein each of said strips is capable of detecting a change of orientation or position.

14. The system of claim **10**, wherein said processor receives signals from said transmitters at a frequency of at least two signals per second.

15. The system of claim **10**, wherein said processor is configured to provide a customized report relating to movement sensed by said plurality of strips.

16. A method of monitoring the performance of a caregiver, comprising the steps of:

providing spaced-apart active capacitance electronic sensors along a portion of a subject support device, wherein the sensors are flexible fabric strips;

periodically querying the active capacitance sensors for signals drawn directly from the subject;

converting the signals drawn directly from the subject to data related to the position of the subject;

transmitting the data to a processor;

processing the data to determine whether significant subject movement has occurred;

tracking information relative to the caregiver; and

outputting the data and information in a user-selected manner related to performance of the caregiver.

17. The method of claim **16**, wherein the electronic sensors are positioned in a mattress pad.

18. The method of claim **17**, wherein the electronic sensors are adhesively secured to the mattress pad.

19. The method of claim **16**, wherein the electronic sensors are queried approximately twice per second.

20. The method of claim **16**, wherein said transmitting step occurs through at least one protocol selected from the group comprising LAN-based data transmission, wireless data transmission, infrared transmission, Bluetooth™ transmission, and RF transmission.

21. The method of claim **16**, wherein said processing step includes time and date stamping of the data.

22. The method of claim **16**, wherein said processing step includes formatting the data for output on a caregiver-by-caregiver basis.

* * * * *